Design Project | Mosquito Trap

The University of Western Australia

ENSC1001 Group E

Anthony Soh	2131 0748
James Hercock	2130 8586
Jordan Ribbons	2131 0908
Kevin Lu	2132 4684
Rowan Withers	2129 4919

Executive Summary

East Timor is currently plagued with a variety of problems, with waste management and malaria amongst those at the top of the list. Upon reflecting on the situation, we have proposed a solution aimed at alleviating some of these issues and equipping the population there with new tools to combat the struggles they currently face.

Our proposal involves the implementation of a simple mosquito trap – an inexpensive solution that would cost the population a reasonable amount that they could afford, in consideration of the poverty that surrounds the area. The solution will simultaneously consider the waste problems there, promoting recycling and the reduction of unnecessary waste that adds to the exponentially growing waste problems in the area.

Due to the large amount of purchases of drinking water in plastic bottles within the area that take up a substantial proportion of wastes (World Bank, 2013), the usage of these traps will provide a considerable change to the level of wastes being thrown away every month, specifically these bottles.

The simple design of the mosquito trap involves using a single plastic drinking bottle to construct each trap, with no specific tools required. This combines both simplicity and efficiency into a single item, which should prove appealing and useful to the population there.

The constraints and issues of this design have been considered and efforts have been made to reduce any negative externalities that could result from our design - be it unhealthy social relations, ignorance of cultural values or being an obstruction to the sustainable development the nation needs. After such consideration has been made, we are confident that the project will result in a much higher social and environmental standard for the population there, with minimal hazardous impact.

By implementing the following proposal, this small change in individuals' behaviour and the spreading of such information could make a large difference in the lives of each and every person living within Timor Leste, starting from the district of Codo and expanding from there forth.

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Introduction and Background

What do engineers hope to achieve in the world today? Is engineering simply about the advancement of well-developed societies and industrial progress, or does it also consider underdeveloped nations and those that need assistance? Engineering Australia expects all engineers within this nation to demonstrate integrity, practice competently, exercise leadership and promote sustainability. In observing that last point, engineers are expected to "incorporate social, cultural, health, safety, environmental and economic considerations into the engineering task" (Engineers Australia, 2010) and that is what this project and its implications aim to achieve.

Timor Leste is a nation situated in the Lesser Sunda Islands found within the Indonesian archipelago, just 500km north of Australia (East Timor Government, 2013). Being this close to the equator, the nation is subject to extremely hot and tropical conditions. During the wet season between December and April, it has an average humidity level of 80% with common monsoonal rains. Due to the high levels of moisture and tropical climate, mosquitoes are common and a problem within the area. Low hygiene levels cause diseases such as malaria and dengue fever to spread rapidly, with little preventative measures or solutions present to assist the less technologically advanced society there (Travel Doctor, 2012).

There is currently no vaccine for dengue fever specifically, and the only way to stop it is by prevention, something that our proposal hopes to achieve (Travel Doctor, 2012). Furthermore, during these rainy seasons, the lack of paved roads within the country causes extremely strained access to healthcare, reducing necessary medical aid further (Timor Leste Government, 2013).

The concept of the mosquito trap that we propose to implement within the region involves the construction of a simple trap with only a plastic bottle being necessary, and common local household ingredients widely available there used as bait. Due to the usage of the plastic bottle in the construction of this trap, this project can counteract waste management problems in the area simultaneously. Considering the fact that consumables are all purchased singularly as per necessity, plastic water

bottles are one of the most common waste products found within society there. Furthermore, no recycling facilities available to allow for proper reusing of this wastes which pose a severe threat to the environment (Engineers Without Borders, 2013).

With these current issues in mind, the proposal focuses on initially providing them with a mosquito trap then explaining to the locals the construction and usage of the trap, such as the combination of ingredients required. The objective of such implementation is to illustrate to the locals the ability to re-use waste that is normally disposed of, specifically in the area of providing a health benefit. This should help the population there have a lower level of plastic bottle waste collected every month, along with reducing the mosquito threat faced in the area that carries with it the much larger threat of deadly diseases.

With special emphasis placed on assisting the development of the population in a sustainable way by reducing their health and waste problems, this project should prove to act as a way of helping Timor Leste progress even further as a nation. Consideration is also placed on the needs and wants of the people there, and whether the proposal will conform to their social expectations and desires. While the proposal in place has little potential to harshly affect the people in any way in terms of having a cultural or exceedingly crucial social impact, we still consider and explore the culture there to see if our project would have any influence (Environment, Society and Culture, 2010). The nation's repeated colonization by Portuguese and Indonesia provides it with a diverse culture, but the many battles that have taken place there lead to a lot of destruction and lack of infrastructure, contributing to the need for health and waste management structures there (Gaglioti, 2011). After all these events that have taken place, the area is currently peaceful since its independence in 2002. Over 90% of the population is Catholic, especially due to the feeling of refuge for those seeking sanctuary from prosecution by the government as the Church is directly responsible to the Vatican instead (East Timor Government, 2013).

With the globalized world as it is today, engineers should be responsible for assisting countries such as Timor Leste that could benefit exceptionally from necessary contributions, and that is what this project aims to achieve.

Approach

Problem Identification

The problem at hand in Timor Leste can be considered an ill-structured problem, rather than the usual well-structured problems that many would be used to facing with a direct, appropriate answer. An ill-structured problem is one that "doesn't yield a particular, certain answer" (Hamblene, 2010, para 1). Handling the waste management in Timor Leste does not have a clear route about it, even though the objective is simple - to reduce the high levels of waste disposed of every year in the region without appropriate recycling facilities present. To consider how to combat this issue, the project has had to take into account multiple constraints present such as cultural issues, the sustainability of the project, potential social impact and many others. In weighing the consequences and positive benefits and attending to the point of view of the population there, the following proposal has been constructed with the belief that it has a justifiable result that will benefit individuals of the area.

Waste management along with hygiene and health are the major areas of concern that require special attention and improvement in East Timor for promoting environmental quality and reducing diseases that are related to the poor environment. The community of Codo's current situation has challenged the group to devise a solution that will address these issues in an appropriate manner. In order to achieve this further research into the social context would be required. The following subsection analyses the principle social impacts that will portray the groups design criteria.

Culture

While many countries around the world boast a history full of rich culture and tradition that has continued to pass down generations, East Timor's people have been strongly impacted by exterior influences such as Portuguese and Indonesian values. (''Culture,'' 2009, Para. 2) With a total of 16 different ethnic groups and 32 different dialects on top of the spread of broken Portuguese and Indonesian, the communication within this nation has lacked flow and continuity causing a growing absence of trust and greater resentment among each other. The exterior influences have resulted in the unique and diverse range of traditional beliefs that East Timor possesses and in a

century that is greatly influenced by globalization, this nation continues to accept cultural expansion. A visible aspect of cultural globalization in East Timor is the disruption of the original belief systems to see an introduction to Catholicism. These changes have potentially weakened trust with the outside world for the fear that history will be repeated and hence potentially affect economy trade globalization. In saying this, it is important to consider the importance of cultural relativism in East Timor. Whilst their economy may have greatly affected their cultural identity, the fact of whether it has provided a positive or negative impact on the people can only be determined with in depth research into the population's current social context. Therefore it is significant to provide a solution that cause minimal to no disturbance with the people's lifestyle and values and since the people are a major stakeholder to this project, this topic will greatly affect the outcome of solutions.

Demographics

East Timor's population is approximately 1.21 million since 2012 (world Bank) with a growth rate of approximately 2.9 per cent each year. This would equal as many as 35,090 increase of persons a year and portrays a steady, linear growth in rate. It is estimated that 70% of the demographics actually resides in rural areas ("Environment, Society and Culture," 2010). Rural Areas such as the town of Codo, spells detrimental implications to the people as issues such as poor road work construction limits the availability of transportation to which looms as an important factor for traveling to and from more developed areas. Developed areas provide access to financial services. The impact of living in rural areas has made it difficult to find new ways to make profit, hence, gives Timorese people no choice but to rely on a source of income from subsistence farming for the basic necessities of life. This shows that when putting forward ideas for a solution to this project, the group must understand that the location of the community of Codo is significant to the outcome.

Agriculture

Despite the implications caused due to a rural environment, East Timor boasts a land full of natural resources. The nation possesses a bountiful amount of oil and gas and marble, along with a fishing zone that expands 200 nautical miles. (''Timor-Leste,'' 2010) In saying this, the majority of the land is utilized for farming and cultivation.

Cultivating crops like maize, sweet potato and rice, to say the least, provide 80% of the population's source of income, with over 40% relying on subsistence from it. (''Rebuilding Agricultural Capacity,'' 2005) This statistic shown provides an idea that successful sustainable development in the agricultural sector can potentially grow into reducing the poverty rate and increasing employment rate. These days, however, with the insecurity of food and lack of development the negative side of it all dominates. Therefore by taking in these factors including insufficient and an unsubstantial amount of income, the project must focus on a cost-effective solution. With a solution that is cost effective and cost efficient the project can substantially help and provide for more, which can lead to many more opportunities such as employment, and health benefits to say the least.

Poverty

East Timor is considered as one of the poorest countries in the world that held a marginal GDP of $1.34 billion (AUD) in 2012 ("Timor Leste," 2012) this is significantly lower in comparison to Australia, a developed country that in the same year achieved a GDP of $1.58 trillion (AUD) ("GDP Current US$," 2012). This financial crisis is mainly due to a traumatic past where the poverty rate proliferated following the Indonesian invasion in 1975 (Gaglioti, 2001). During this invasion around 75% of the countries housing stock were destroyed by the Indonesian military (''East Timor-Housing,'' 2007). The destruction of houses left thousands homeless leading to a large number of East Timorese people being forced to live below the poverty line with minimal resources to live off day to day. Figures illustrate that from 2001 the percentage of the population living under $1.30 dollars (AUD) a day increased from 36.3% to 49.9% in 2007 ("Timor Leste," 2012). Poverty is a major issue in many countries around the world today and engineers have been challenged to continue endeavouring to help solve this situation. The ability to support the future in poverty related society's like East Timor leads to the factor of sustainability and durability. For that reason the solution must satisfy these factors in order to be successful.

Health

The poor environmental conditions involving scarce food availability, malnutrition, sanitation and limited resources influence the health in East Timor. This has resulted in a large growth and spread of preventable diseases throughout the nation. Malaria is an example of a proliferating parasitic health concern that occurs all year round. In 2009 this parasitic disease was the cause of 9,566 deaths per 100,000 East Timorese people (''Malaria and Tuberculosis,'' 2010). Another concerning parasitic illness is Filariasis, specifically amongst East Timorese children. The parasite causes elephantiasis, which is a chronic swelling of the limbs (Everingham, 2013). These are only a few of the health issues that are plaguing East Timor, however as evident in the facts above, the parasitic health concerns such as malaria represent a remarkably serious issue in East Timor's rural areas. There are many others such as hepatitis A and B, tuberculosis and HIV all of which can be prevented or treated in some way. These negative health facts illustrate a deficit in health supplies and services. Poor sanitation and an infected water supply is one of the main contributing factors to the spread of the diseases such as malaria and tuberculosis (Lewis, 2010). Only 58% of East Timorese people have access to safe water ('' Safe Water and Sanitation,'' 2008). Clean water supplies are not the only scarce resource. There is a growing demand for access to health care professionals. Health care for people in particular districts is especially difficult to attain during the rainy season due to the lack of paved roads. This is why the development of medical facilities in rural areas is a strong concern of the government. As a result a project with a secondary benefit that may go hand in hand with the health sector is a positive outcome that can save and help many lives in East Timor.

Climate

The climate of East Timor not only affects healthcare indirectly through making transport more difficult but also is directly responsible for the spread of malaria and other diseases. East Timor's climate is characterized as a tropical zone, prone to flooding and high temperatures. This along with large volumes of un-sanitized water provides breeding grounds for the disease-causing parasite (''Climate Overview,'' 2008.), which only further increases the risk of malaria and other health crisis throughout East Timor. Understanding that the climate in East Timor is a major

contributor that provides a perfect atmosphere for mosquitos to breed, spread, and infect, one that already causes perilous health issues, reassures that this serious problem needs full attention. Climate can greatly affect whether a solution is effective or not, therefore this project should look into the factor of weather resistance so that it may be effective all year round.

Education

Due to the destruction of 90% of school buildings and loss of up to 80% of its teachers during the Indonesian siege of East Timor, the country's education system suffered a hardship, only to be partially rescued by aid organizations that rapidly restored 700 of 800 primary schools' educations by May 2000 (''National Encyclopaedia- Education,'' 2011, Para. 2). However, in 2001 the literacy rate of individuals 15 and over was a mere 48%, with only 18% of adults having secondary education and 1.4% higher education. Despite efforts in constructing an effective education system, difficulties are still faced such as families that lack in income to provide their children education. Instead, parents of East Timor choose to coerce their children to work to earn money for the family while depriving their children of the education so desperately needed for a better future in the long run. Lack of education represents the need to avoid complex solutions to this project. As shown in the facts above, the project must not be sophisticated but can easily be interpreted and understood, a solution that focuses on the essence of simplicity.

Sustainability and Sustainable Development

As the population grows at an increasing rate, so do the needs and desires of sustainable development within the country of East Timor. As engineers, sustaining civilizations continuing advancements not only through materialistic innovations but also through expressions of actions and interest, while still improving the quality of life for generations to come, is what clarifies the meaning of sustainable development. Through the major topics explained above it is evident that the Timorese People live a lifestyle that focuses on withstanding poverty related conditions to achieve the basic necessities of life. Therefore the outcome solution that will be put forward must aim at sustaining not only the waste problems taking place in the country but also the lives of the people in East Timor. The group believes by developing a solution with the

resources that are viable to the community of Codo's needs, the group can effectively aim to incorporate a sustainable system that will meet the needs most sensitive to the people including environmental waste management and will provide for its future.

Ethics

An ethical solution is a difficult process that requires the group to fully understand the community of Codo. When looking to formulate a solution the group must amalgamate East Timor's social context with the population's moral principles for an effective, ethical result. In saying that, ethical questions like: Is the solution respecting the stakeholders interests; and is the solution aware of the citizens health and safety and whether the solution is breaking any of their laws arise which must be considered. The group intends to devise a solution that will have minimal impact towards social beliefs and values and most certainly not cause any such harm to the people. Hence, the group must apprehend what is acceptable in the practice of engineering and inhabit a social responsibility and professionalism for the project. By planning this, the outcome solution will be more sustainable and effective in addressing the issue not only for a temporary basis but also for a long-term situation. To achieve this the group believes that approaching each topic related to East Timor diligently and respectfully whilst also visualizing the nations social context in all distinct angles will minimize and come very close to providing a solution that will apprehend the ethical element of the final solution that will be put in place in East Timor.

Globalization

Following East Timor's Independence the nation was challenged by an economical crisis (Whitman, 2004), which consequently widened the gap between the rich and the poor. This resulted with a tremendous 50% increase in poverty rate and continued to threaten the population from risks such as starvation (Lundah & Sjoholm, 2005). Nonetheless the globalized economy's increasing interconnectivity between countries markets and culture has opened up East Timor to the world where the nation experienced a sudden boost towards East Timor's economical growth. With the abundance of commodities that the nation possesses, this expanding society continues to show signs of opportunity towards the economy and its people. The Timorese people have observed improvement in employment rates, and have been introduced

foreign medication treating their preventable yet common threatening diseases. However the effect of globalization has also caused an uncontrollable waste problem hurting the nations environment, economy and people. All of this relating to the power of globalization, providing the ability to understand and witness what the real issues that are causing such inequality in the world we live in today. As engineers, the project aims to compose an answer to fight against the negative consequences that globalization has exposed. This is what the group has discussed as an important concept to survey before laying out the final solution.

Simplicity

Throughout the project the group recognizes many stakeholders who are troubled by the waste problems in East Timor. This includes the government sector, the businesses and most importantly the local people. In saying this, it is found that in the area of Codo there are two types of waste that currently dominates, these are: organic waste such as food scraps, and non-organic waste like plastic bottles and the packaging from products (Engineers Without Borders, 2013). Therefore the group believes that it is self-evident that it is in fact local consumers, the community, who primarily litter these types of wastes. From this the group identifies the lack of public awareness on waste management in Codo. This leaves the group pondering on the importance for the final solution to contain an aspect of awareness for the local people in what is really going on around their community and on top of that the group also believes that the local people are major factors to East Timor's waste management solutions. As a result the group has agreed to focus on implementing a solution that concentrates on the essence of simplicity for the community. The concept of simplicity was emphasized in order to not potentially alienate those who had not had the privilege from taking part in the project in their own homes. That is, bring about a cohesive-like attitude so that everyone is participating to make a change and so that the people do not feel like they are controlled.

Preliminary Design Choices

Being well aware of the problem at hand, there was no shortage of ideas for potential design solutions within the group however it had to be narrowed down to a select few possible solutions and then further to the final one solution that would be researched and developed further to provide the people of East Timor with the most viable and effective solution to the waste management problem. The list of five potential solutions the group had decided on was as follows:

- Water Filtration
- Shared Bulk Packaging
- Alternative Packaging
- Mosquito Trap/Mosquito Reduction Device
- Rainwater Tank

Decision Matrix

The formulation of the decision matrix required the process of determining what specific criteria the potential solutions have to be assessed upon. Advancing one step further, the group not only determined various criteria but also assigned a specific weighting out of 5, in terms of perceived 'importance.' The designs would be scored individually according to the criteria and then the score would be added up out of a total of 25 points. The criteria chosen and weighting given with a score of 1 being poor and a score of 5 being excellent were as follows:

- Sustainability – 4
- Social Impact – 4
- Environmental Impact – 5
- Cost/Resources – 2
- Feasibility/Implementation – 3
- Safety – 3
- Effectiveness – 4

Solutions	Sustainability 4	Social Impact 4	Environmental Impact 5	Cost + Resources 2	Feasibility + Implementation 3	Safety 3	Effectiveness 4	Total 25
Mosquito Trap	2	4	3	2	3	1.5	3	18.5
Rainwater Tank	3	3	4	1.5	2	2	3	18.5
Water Filtration	3	3	4	0.5	1	3	2	16.5
Shared Bulk Packaging	2	2	3	2	1	3	1	14
Alternative Packaging	3	2	5	1	1	3	3	18

Table 1: Decision Matrix

Design Criteria Break Down:

Sustainability

This factor was deemed as very important due to the fact that an unsustainable solution to the waste management problem has the potential to be detrimental rather than good for the area of Codo and its people. It would be impractical to have a non-sustainable option, as the aim of the entire project is to help alleviate the waste problem in Codo and improve the people's lives, not just for a week or a month, but also as an ongoing measure.

Social Impact

This particular criterion was also deemed as very critical. This is because cultural difference can play a huge role as to whether a project will be a success or failure. (Armstrong & Tavner, A 2013, p. 161-167) A great deal of research was done into learning about the people of East Timor, more specifically the people of the Codo region and each solution was scored relative to the perceived 'acceptance' of the project by the people. Also falling under social impact was additional benefits to the people other than alleviated waste and this was also contemplated relative to each solution and added to the score given for social impact.

Environmental Impact

This particular factor was weighted the highest out of all the chosen criteria. This is because the entire project is based on alleviating a waste management problem, which directly falls under environmental impact. The factor was looked at from two different perspectives. One being: how much wastes will this solution reduce? The other view

being: What's the environmental impact of creating, implementing and then sustaining the solution? These two views were looked at independently and then put together to determine a score.

Cost/Resources

Due to East Timor being a developing country with 49.9% of its residents being below the national poverty line (World Bank, 2012) means that there are no large amounts of funds that can be drawn upon for the proposed project from the country itself nor can the residents afford to contribute financially. Considering this particular economic context the team scored the potential solutions correlating to how cost effective and inexpensive they were. Not only to create and install but to run. For example: maintenance costs etc.

Feasibility/Implementation

This criterion dealt with just exactly how viable the given solution is both to implement and in regards to the context of East Timor. Each solution was critically analysed logistically in order to determine just how easy or difficult the particular solution would be to implement and the questions asked: 'can this solution actually work?' 'Is it feasible?'

Safety

Safety is paramount when implementing a solution that is intended to help people not be a hazard so safety was an easily justifiable factor in the decision matrix. Each design choice was critically assessed in terms of how it could be a potential safety hazard. For example: the water in the rainwater tank could be potentially contaminated and the construction of the mosquito trap could result in minor lacerations to the hand when cutting the bottle. All of these safety considerations were weighed up and compiled into a score with a higher score deeming the given design as 'safe'.

Effectiveness

This factor was weighted very highly and was looked at from two different angles. The first being in regards to how effective the design would be in alleviating the waste problem and improving waste management. All of the proposed solutions were compared to each other in terms of which would have the greatest positive impact and effect on reducing waste and the scores were determined relative to each other. The

other angle being how effective the design is relating to any other intended purposes it has other than waste management.

Social Issues intended to be addressed by the Design as follows:

There were many social issues that were identified as having the potential helped and alleviated by the design solutions that were chosen. These issues, aside from waste management included things such as poverty and health and sanitation issues, for instance, access to clean drinking water and high malaria rates. Ideally, the final solution should be able to not only be reducing the amount of waste but also having secondary social benefits that increase the East Timorese quality of life through things such as providing clean drinkable water through the rainwater tank or reducing mosquito borne diseases through the mosquito reduction device and that is what the team aimed for.

Poverty

Poverty is prevalent in East Timor with as stated earlier, 49.9% of the population below the national poverty line (World Bank 2012). All proposed design solutions were considered with this fact in mind. There were no costly proposed design solutions as the team focused on providing very cost effective solutions that financially, would have no great impact on both the people of East Timor and its government. Although this does not directly 'address' the social issue of poverty, it does not worsen the financial situation of the people while still providing a positive impact.

Access to Clean Water

Another social issue identified was access to fresh drinking water. There is an alarming statistic that 41.4% of the rural population of East Timor do not have access to clean water. With the region of Codo being rural the solutions proposed took this fact into account. Both the rainwater tank and water filtration system designs aimed to provide access to clean, drinkable water for the residents of Codo. This issue is not unknown to Australia as AusAid's rural water and sanitation program has already achieved in providing 77,000 rural East Timorese people with safe water (AusAid 2012). Due to this, the team also wanted to play a role independent of AusAid and help in increasing the access to clean water for more rural East Timorese.

High Malaria and other Mosquito borne Disease Rates

Whilst researching the health and sanitation context of East Timor it was made apparent that malaria and other mosquito-induced diseases are a significant health related social issue in the rural regions such as Codo. There are 52 species of mosquito in East Timor, many of which carry a range of diseases (Whelan & Hapgood). A survey conducted in Dili, East Timor's capital found that 55% of houses were home to mosquito breeding sites. A range of various water receptacles were tested and it was found that plastic bottle waste was the most prevalent form of breeding site used by mosquitoes due to the confinement and traces of water left in the bottle (Whelan & Hapgood, 2000). Malaria is the second most common source of disease in East Timor (Nick Anstey, 1999) and along with Dengue Fever was the cause of 11.1% of East Timorese hospital patient deaths in 1998. Taking all of this into consideration, the team tried to devise a solution that could potentially alleviate the waste problems whilst also reducing mosquito borne disease rates which have a positive effect health-wise for the people of Codo

Preliminary Designs

Rainwater Tank

According to the decision matrix the rainwater tank design solution was a very close second to the mosquito trap solution. The group disregarded the scores as they were so close and looked at the two designs, comparing them with one another. The basis for not progressing with the rainwater tank idea was due to there is already being so much work done from foreign aid in terms of providing clean water to the rural areas of East Timor and a much lesser extent of reducing mosquito borne diseases. Along with this, the team was more inclined into developing a more innovative and creative design such as the mosquito trap rather than a water tank.

Water Filtration

Whilst this idea would be extremely safe and have a great environmental impact through the reduction of plastic bottle waste, the feasibility and costs involved for our particular filtration system made this project too impractical to be implemented in the region of Codo.

Shared Bulk Packaging

This design solution entailed the formulation of a system which enables the people of Codo to buy their goods in bulk collectively with others rather than individual purchases. For example, instead of buying a single sachet of washing powder for one load of washing, a group of 5 households purchases a box of washing powder to share amongst them. The reason the group chose not to run with this solution was because of the unknown social impact this may have on the people. There is potential for people to take more than their share, steal from others etc. So it is quite possible that socially this solution would cause more harm than good. In addition, when weighed up against other solutions in regards to effectiveness, this solution does not make the cut.

Alternative Packaging

This solution focussed on helping East Timorese suppliers of goods to adopt alternative packaging of their products that have a much less negative environmental impact such as biodegradable or recycled packaging. In theory it is a good idea, however, in practice it would be extremely hard to implement. These alternative packaging methods are very costly, so companies would be very tentative and disinclined towards going down this route. Even if they were to adopt these alternative methods, this would mean they would have to make more money to cover the new expenses and this passes down to the consumer. The East Timorese people would not be able to afford this additional cost and this would lead to more social problems. For these reasons, the group decided against this design solution.

Design Choice: Mosquito Trap

The group settled on the idea of the mosquito trap for its originality after the decision matrix stage left the mosquito trap and rainwater tank on equal plausibility. This decision was based on the notion that in all likelihood some form of rainwater collection would already be put in place and that more attention is being given to fresh water in terms of awareness and aid, so the group opted for the mosquito trap which would be addressing a less thought of though potentially more serious issue.

Stakeholder Analysis

The mosquito trap design has a noticeable effect on several stakeholders in the area, including the general population and government of Timor Leste, above most others. The improved waste management of plastic bottles that are currently excessively disposed in the nation can only be achieved by the participation of the population, and also benefits the population more than any other party. Health benefits such as the reduction of mosquito-borne diseases has a positive effect on the lives of the people living there as well, while affecting another stakeholder – the government. By proving reduced risk of such diseases occurring in the country and greater health standards, tourism levels and the willingness of individuals of other nations to come into the country to raise its economic and welfare standing will naturally increase as well. The following

Stakeholder	Environmental	Social	Economic
Local people	+	+	+
Government	+		+
Local businesses that sell insect repellent			-
Local businesses that have an interest in outdoors			+

Table 2: Franklin Plot

As illustrated on the following Franklin Plot, other minor stakeholders are also impacted by this project, including several local businesses. For those who make an income based on selling products that repel insects such as sachets, they will face a negative economic blow due to the lack of necessity of such products. However, these products have proven to increase waste problems in the nation due to their short-term use and the reduction in their sales could prove to be beneficial for waste management in Timor Leste. Furthermore, these products are often sold in general stores that find business from many other items and should not negatively affect owners of such business excessively. Companies with outdoor services such as hiking and touring also face positive economic effects due to the increased business they can expect to receive. In considering all the potential impacts on such stakeholders, we have designed the following proposal.

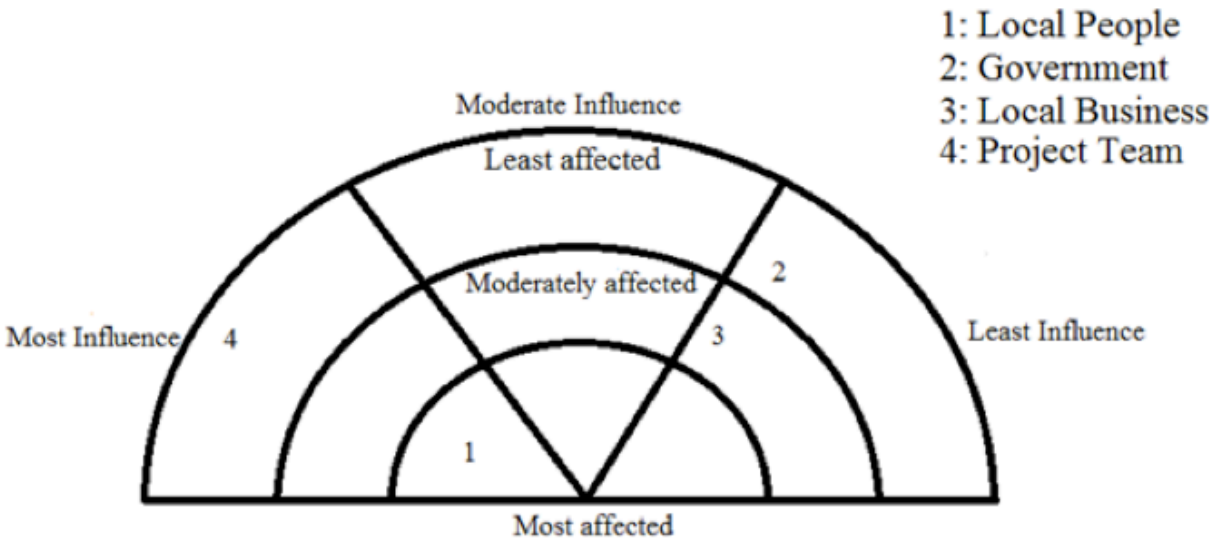


Figure 1: Rainbow Plot

Final Design Alternative Choices

After the Mosquito Trap was elected final design choice, the group came across a couple of different design solutions:

1. Mosquito Trap made of recycled plastic bottles
2. Mosquito Trap made of recycled paper / cardboard-based bottles

The difference between both viable options is the main outer three-dimensional material. When researching into the types of waste that was evident to be found in East Timor, there was not only a large portion of plastic bottles but there were also large amounts of paper and cardboard wastage from product (Engineers Without Borders, 2013). At first, paper and cardboard-based Mosquito Traps seemed like a very viable solution not only due to its abundance and easy access but it appeared to have a higher safety factor in comparison to plastic bottles. That is, plastic when cutting can create sharp edges that could lead to minor or even major cuts and the group was strong in emphasis to the safety aspect of the project. However the group kept coming across, newer and more complex obstacles that prevented further progress for the cardboard and paper option. For example cardboard and paper is not easily found to be in a three-dimensional state when found, there is a high chance that requires the cardboard and paper to be molded with a machine like tool for a much required shape for the Mosquito Trap to work. This then leads to higher costs and longer time to complete a simple solution, two factors that defy the most important aspect of the desired solution. On the other hand, plastic bottles are readily found in abundance and in a structure that allows an immediate construction of the Mosquito Trap. For this reason, the plastic based model of a Mosquito Trap was chosen. Additional features of the design needed to be tested and proven first before choosing final design features and are therefore represented in Table 4 in The Results Section.

Sustainability

The mosquito trap solution turns out to be highly sustainable as it has minimal cost to produce and replace if needed, while simultaneously reusing and reducing waste. The trap would not easily break and simply would require the contents to be cleaned out and refilled in order to be used again, and in the rare case that the trap was broken it would simply require one plastic bottle to replace it.

Social Impact

The social impact of the mosquito trap design is more related to the health impact of the design, reducing the health issues of malaria and dengue, which are transmitted by mosquitoes and are problematic in East Timor. In 1998, 11.1% of hospital deaths were reported to be caused by malaria or dengue (Anstey, 1999). Any reduction in the contraction of these diseases will bring about a positive social impact on the community.

Environmental Impact

This solution has a direct positive environmental impact by reusing waste plastic bottles that potentially pollute the local environment directly or pollute the atmosphere via incineration. A secondary impact that this solution has is that it reduces the use of aerosols, which can affect the atmosphere, and it also reduces the waste insect repellent sachets that are used by locals as a means to reduce insects currently, including mosquitoes (Whelan & Pettit, 2005).

Cost/Resources

The monetary and resource cost of the mosquito trap is tied to the cost and availability of brown sugar (AUD$0.23/100g) and yeast (AUD$1.66/100g) These prices were calculated by comparing the average costs of groceries in Australia and East Timor and applying the same ratio to yeast and sugar prices. ("Cost of living in Timor Leste", 2013) for locals, as such it requires little money and just needs the user to warm some water (not necessarily drinking water since this resource is scarce) and cut the plastic bottle in half. This would be costing the locals an average AUD$0.08 per fortnight per device (Assuming a rough average of 2 grams of yeast and 2 grams of brown sugar). As mentioned above, this solution reduces the need for locals to buy insect repellent sachets, which cost around AUD$0.11, helping locals save what little they have in their daily budget (Whelan & Pettit, 2005). For this design the contents of the trap should typically be refreshed every couple of weeks (Waihou, 2012), and as long as care is taken when the contents if refilled, the bottle itself would not necessarily require replacing at all.

Feasibility/Implementation

The simplicity and low cost of this design makes it very feasible and easy to implement. Minimal instruction would be needed to construct it and its use once built is relatively straightforward. These aspects gave the mosquito trap the highest feasibility among all of the design choices. The design is fairly simplistic, involving nothing but a plastic bottle, water, brown sugar and yeast. Its construction is based on the notion of carbon dioxide baiting for mosquitoes, with various versions of the design in existence, each design slightly different from the next. The steps required for the construction of the design are as follows:

1) The plastic bottle is cut approximately one third of the way down from the top of the bottle.

2) Water is warmed to a lukewarm portion of the plastic bottle, filling up to one third of the lower portion of the bottle.

Figure 2 (i)

3) Brown sugar is added to the warm water and stirred; the amount of sugar should be approximately one or two teaspoons. (Equivalent to yeast)

4) One to two teaspoons of yeast are added to the water and stirred.

Figure 3 (ii)

5) The upper portion of the bottle is inverted and inserted into the lower portion, then tape is wrapped around the bottle to hold the top on, however tape may not be required if the top fits into the bottom snugly.

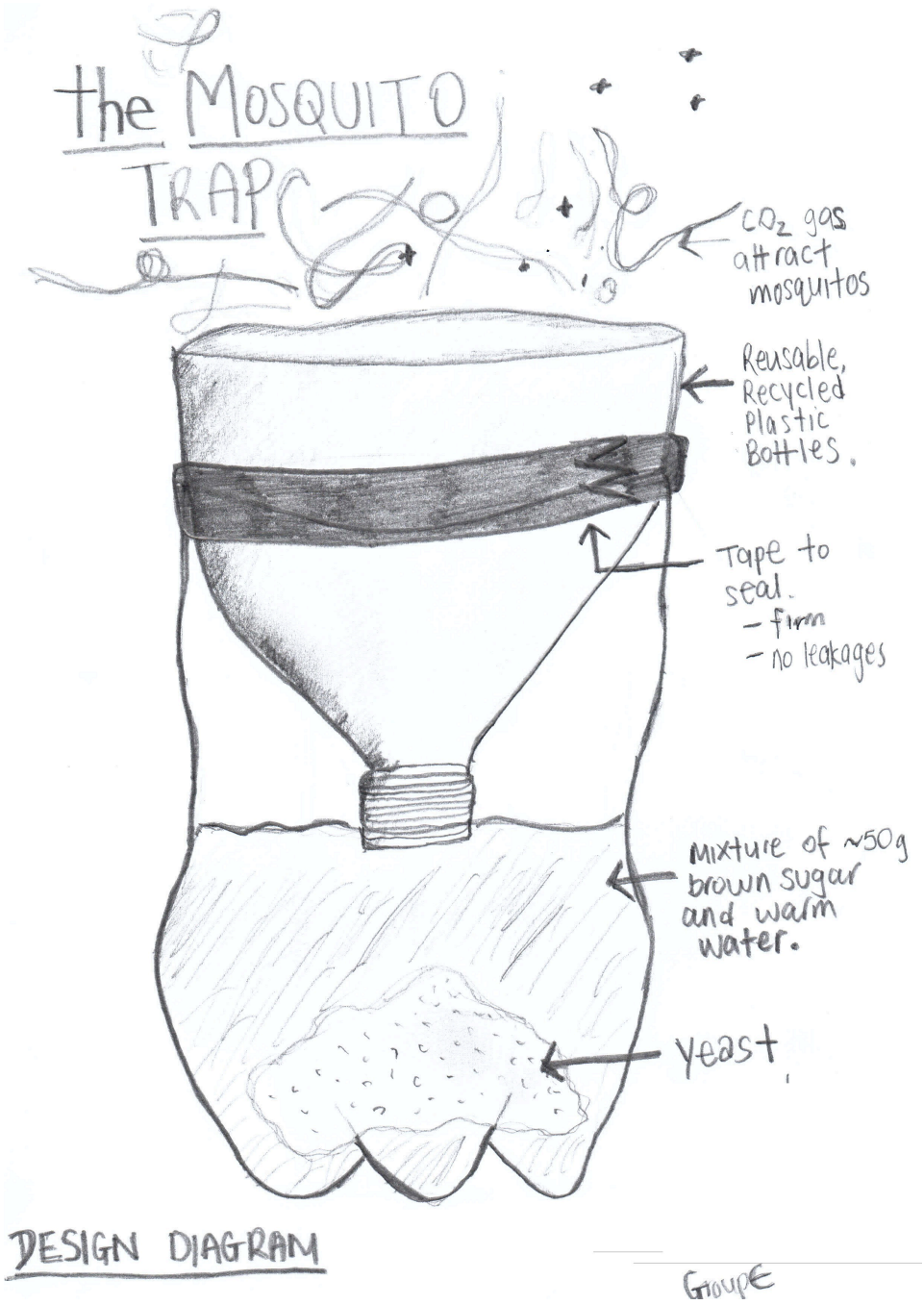
Figure 4 (iii)

6) Optionally dark material/paper can be wrapped around the bottle. (Waihou, 2012)

7) Every fortnight roughly remove the top portion of the bottle, empty the contents, and then repeat steps 2 onwards (Waihou, 2012).

Figure 5 (iv)

Figure 6-Detailed Diagram of Mosquito Trap



The way the group decided to implement and start the Mosquito Trap in East Timor was by providing a simple flyer with simple to read instructions in four different languages: English, Portuguese, Tetum and Indonesian. The Flyer mainly portrays step by step follow through images that helps the community people how to set up the Mosquito Trap as the materials required are all acquirable by the people themselves. Refer to Appendix C for example of potential Flyer.

Safety

A couple of minor safety risks exist for the design, for a full analysis of the risks involved in the design. Primarily the main risks of the design are during the initial construction of the trap, when the bottle is cut there is a risk of minor cuts, and during any replenishment of the trap there is a small chance of burns caused when the water is warmed up enough to dissolve the sugar.

Risk Assessment Table:

Consequences	Likelihood	Exposure	Risk Score
Minor Cuts (1)	Unusual (3)	Occasionally (3)	Low (9)
Minor Burns (1)	Unusual (3)	Rare (1)	Low (9)

Table 3: Risk Assessment Table

Besides the safety risks in association with the construction of the Mosquito Trap, the only other factors that are relevant is the safety of the actual yeast substance to certain external sources such as young humans.

Therefore the group has also taken into account the possible safety risks that may occur when near local households, especially children. Firstly if there was a situation where children may misinterpret the active yeast solution as a drinkable substance, the result is evident to have less to no harm to the children. This is because the Mosquito Trap itself only uses a very minimal amount of yeast substance each time (~1-2 grams) therefore the consumption of the yeast will only provide a little to no pain in the abdomen area as a result of the yeast actively consuming sugars in the stomach, but in no time the acidity levels of the stomach will eventually destroy the yeast. (Fitzpatrick, n.d. page 4) However this is of course assuming the fact that the children do not have an allergy towards yeast. If that is the case, a doctor may need to be consulted for further directions.

Effectiveness

The mosquito trap is relatively effective at its intended purpose of trapping mosquitoes, it proved to have limited effectiveness during testing in Australia, however the conditions in the Codo area would allow for the design to be more effective. The trap would be most effective in warm areas with relatively still air and nearby still water, however out of the rain (perfect living conditions for mosquitoes) (Whelan, P. & Hapgood, G. 2013, page 4-6) Locals should not use the traps inside their homes as the carbon dioxide attracts the mosquitoes, potentially attracting more mosquitoes to residents than to the trap itself. (For a more detailed analysis of the effectiveness of the design, refer to the following results and discussion section). It has somewhat limited effectiveness in reducing plastic bottle waste as only a finite (yet very high) number of these traps can be constructed before they start being useless, however the traps will continually reduce the waste insect repellent sachets, a potentially endless contribution towards helping the environment.

Results and Discussion

As described in the Final Design Choice Section the Mosquito Traps simple structure of recycled plastic bottles collected from Timor Leste's waste environment aim to eliminate disease-carrying parasites and mosquitos by imitating a scent mechanism similar to the human body. We have considered the fact that despite the research on the optimal combination of ingredients and materials, consideration has to be placed that the sources may not be fully reliable and applicable to our project. In order to critique the information obtained rather than blindly follow it, to ensure the effectiveness of the trap, we perform multiple tests on different samples varying slightly in the materials used. With the difference in climate conditions between East Timor and Australia, a major factor to the outcome of Mosquito Trap results, its testing is not very practical or feasible. Regardless the limitations, the group decided to place a number of Mosquito Traps in two different locations, the typical suburban backyard and a creek bank. Many variables, excluding the climate, as it was inappropriate to compare with East Timor's, were considered such as the size of the plastic bottle, the concentration of yeast and sugar, and the time it was left out.

Test	Bottle Size	Time Left Out (Days)	Location Placed	Amount of Sugar/Yeast used	Fruit Flies Caught	Mosquitoes Caught
1	600mL	1	Suburban Backyard	1 teaspoon of each	24	4
2	1.25L	1	Suburban Backyard	2 teaspoons of each	29	7
3	1.25L	1	Suburban Backyard	4 teaspoons of each	34	9
4	750mL	1	Suburban Backyard	1 tsp yeast 10 tsp sugar	3	0
5	750mL	1	Creek Bank	1 tsp yeast 10 tsp sugar	17	3
6	250mL	1	Creek Bank	1 tsp yeast 5 tsp sugar	8	0
7	250mL	5	Creek Bank	1 tsp yeast 5 tsp sugar	19	6

After a considerable amount of testing prototypes of the mosquito reduction device the results were as follows as the table above:

Table 4: Results Table – Design Matrix

As seen in the above table, the mosquito trap was successful in catching mosquitoes. Unexpectedly, it was found that the device was also extremely successful in catching fruit flies. Fruit flies are similarly attracted to the release of carbon dioxide, as this is what fruit does when it turns rotten. For this reason the fruit flies were very much attracted to the device as they mistook it for rotting fruit, same as the mosquitoes mistaking it for a mammal. (Pulver, 2013) Despite not expecting fruit flies, the fact that so many were caught was pleasing. It meant the device was releasing carbon dioxide and could very well catch mosquitoes, which is what was intended. The fact that the number of fruit flies caught far outweighed the number of mosquitoes caught was simply put down to the fact that the population of fruit flies in both locations the trap was placed greatly outnumbered the population of mosquitoes. In saying this, there were a number of different variables and factors all-attaining to how many mosquitoes (and fruit flies) were caught.

Variables and Discussion of Mosquito Trap

Bottle Size

After experimenting, this variable was written off as a contributing factor to the capturing of mosquitoes due to the fact that its sole task is to act as a vessel for the varying amounts of yeast and sugar. It merely holds the ingredients in one place and varying the bottle sizes played no part in increasing or decreasing the amount of mosquitoes caught.

Time Left Out

As was expected, the longer the amount of time the device was left out in the open resulted in an increase in mosquitoes caught. Tests 5 and 6 were identical apart from how many days they were left exposed to the environment. Test 5 was left out for one day and resulted in no mosquitoes caught as opposed to test 6 which was left out for 5 days and resulted in 6 mosquitoes caught. This shows a direct correlation between time and number of mosquitoes caught. Despite the correlation, it was found that even though test 6 was left out for a length of time that was 5 times longer than test 5, there

was not an increase of a scale of 5 in regards to mosquitoes caught. Therefore, it is assumed that the trap may lose effectiveness over time.

Location Placed

This variable is somewhat ambiguous as it is very difficult to distinctly differentiate the two locations other than the fact that one is in close proximity to a body of water and the other is not. It was initially hypothesised that the Creek Bank location would induce a larger amount of mosquitoes caught than the Suburban Backyard (no large body of water present) placing due to the fact that mosquitoes are prevalent in such areas because of their reproduction habits on bodies of water (Gaines, 2011). This was backed up by the results between tests 4 and 5, which were identical apart from the locations in which they were placed. Test 4 caught no mosquitoes whereas test 5 at the Creek Bank caught 3. Due to there being no significant body of water found in the residential backyard it can be inferred that there were less mosquitoes present than at the Creek.

Amount of Sugar and Yeast Used

From the results, it was evident that this variable was the most influential factor in regards to how many mosquitoes (and fruit flies) were attracted to the device and succinctly trapped. It was found that despite tests 1,2 and 3 being located in a less dense mosquito populated area they still managed to catch and trap a great deal more mosquitoes than tests 5 and 6. It was concluded that an equivalent sugar to yeast ratio was optimal and that the chemical reaction between the yeast, sugar and water was more effective at this ratio in producing carbon dioxide, which therefore attracted more mosquitoes. Comparing test 1 with test 4 further backed this up. Test 1 had 1 teaspoon of both yeast and sugar whereas test 4 had one teaspoon of yeast and 10 teaspoons of sugar. There was a vast difference between the amount of mosquitoes and fruit flies caught as can bee seen in the table.

Another trend evident regarding yeast and sugar amounts was that along with finding that an equivalent ratio of sugar and yeast was optimal, an increase in both sugar and yeast also resulted in the entrapment of more mosquitoes. This is easily explained chemically due to the fact that an increase in reactants (yeast and sugar) will naturally result in an increase in products (carbon dioxide) (Whitley, 2009). The more carbon dioxide produced, the more mosquitoes attracted to the device. Despite this, tests 1, 2

and 3 were identical apart from a doubling of reactants, however the amount of mosquitoes did not double when the reactants were doubled. The increase in mosquitoes caught was only very minimal and for this reason it was deduced that the increased cost associated with increasing the reactants would not be cost effective and simply not worth it for the people of East Timor, taking into consideration the poor economic condition in which they live. Therefore only a minimal amount of reactants is needed to be successful.

Design Failures

Due to the mosquito trap being a solution of utmost simplicity, through the process of creating numerous, varying traps the team did not encounter any 'failures' as such. There were no materials or tools that resulted in failure for any one of the created traps. This is due to the fact that not much at all is needed in order for it be constructed. Simply a sharp object to slice the bottle in half, the plastic bottle itself and both the yeast and sugar is all that is required. The minimal amount of different components and simplistic nature of the design lead to a failure rate of nil for the construction of 13 mosquito traps over the course of the semester. However a potential design failure that may occur theoretically but have not been proven experimentally is the specific placement of the actual mosquito trap that could cause it to topple onto its side. Though if this was to happen in East Timor there are definitely a countless number of ways to stabilize it. Particularly placing it into something sturdier, or placing within a few centimetres into the earth.

Other Considerations

Despite the mosquito reduction device being successful here in Perth, Australia, it is believed the device will be a great deal more effective in East Timor. This is mainly due to the difference in climate and weather conditions. Perth is relatively dry and the tests of the device were conducted when rain had not occurred for 15 days. Rain and mosquito populations are directly correlated as more rain leads to more water sources accessible in which the mosquitoes can breed. (Gaines, 2011) Climatically, East Timor is very tropical and is subject to monsoonal seasons. From December to April, East Timor is subject to the 'wet season', which includes incredibly heavy monsoonal rains. These rains are so heavy that they cause flooding and landslides and directly correlate to a huge increase in mosquito activity (Szczepanski, 2008). For this reason,

it is believed that the mosquito activity in East Timor is much more than that of Perth; thereby the device will be more effective than what our results have shown.

To maintain a certain relation towards the community collaborators whilst working on a solution is not appropriate, as the group understands that this is an ill-structured problem. The fact that this project is taking place in Australia, but aimed to be implemented in East Timor makes it very difficult to co-operate with the community. For that reason by judging the adequacy of the Mosquito Trap for East Timor, a lot of research and testing has been conducted to cover and address as many of the needs that the group understands to be relevant within its community. Research through appropriate articles, scholars and websites through the Internet has been the most important and appropriate way of communicating their lifestyle and economy to the group. The research done provides a solution with what the group agrees to be an influential idea. That is, allowing the community to make sure they do not feel like 'clients' but engaged participants who have the power to make a difference to how the project will be carried out within its community.

Team Process

In order to develop an original design and effective solution our team needed to not only work in an equitable way but also had to go through a complex process of research and idea development. This involved creating a work breakdown structure and Gantt chart as seen in Appendix D, which gave an insight into the necessary tasks that needed to be completed in order to achieve this. It also involved making a SWOT analysis of the team to identify what the team could work on or take advantage of. The team also made a team charter, which would allow any problems to be easily resolved whilst ensuring fair distribution of work. This ensured that there was continually a diversity of ideas adding to the creativity process to produce an original design. The creativity process also involved in-depth research into the social context, producing potential solutions from that knowledge and finally choosing a design.

Team Management

In order to combat all problems that may arise during the project lifecycle, the team went through a simple process of recognizing potential problems and how they would be mitigated. Major team and project management issues that were likely to arise were disagreeing on important decisions or other information, not meeting deadlines, having one member fall behind in their work, unfair distribution of work and lack of communication among group members. These are all issues that the group quickly addressed to ensure that all team members participated in a manner that ensured all members contributing to the development of the design.
To ensure that all deadlines are met, all work will be completed two days before those particular deadlines. This will ensure that the project does not fall behind schedule and that no team members fall behind.

The group will actively listen to each other and let every group member voice their opinion in an open environment. We also make every effort to compromise and use a consensus vote to make important decisions after weighing up implications of important factors affecting our decisions.

We aim to have equal distribution of all tasks and implement the rotation of roles to have diversity of work for all team members and a variety of input in all areas. If a team member feels they have exceptional skills in a certain area, they will be welcomed to take charge.

All team members will be responsible for ensuring they regularly check for updates on the progress of the project as well as communicating any issues, ideas, feedback or discussion as needed. The group is committed to meeting in person for at least one hour per week as far as their university and/or work schedules will allow.

Team Analysis

Throughout the project, the team found that we had many strengths and weaknesses. We did our best to recognize these early on and turn them into opportunities or try and avoid any threats. The team recognized that some of the strengths we had were respecting each other's opinions and input, researching skills, proactivity in starting work, and communication. These strengths allowed the team to ensure all labor was divided equally among team members which gave ideas a level of diversity; ensured that decisions were made on a democracy system which allowed all team members to be happy with the final decision and mitigate potential problems; turn any setbacks into opportunities as the team's strength of perseverance allowed us to overcome problems easily and all team members committed to finding a solution; by being proactive the team kept to the schedule a majority of the time; and lastly by having great skill in researching, we managed to mitigate the threat of not being able to communicate with the people of East Timor. Although some weaknesses were recognized, these weaknesses were quite minimal as they only occurred at certain times instead of the entire project lifecycle. This meant, that although at times we had weaknesses as a team, they were easily overcome and a majority of the time that weakness turned into a strength.

Strengths	Weaknesses
• The team supports each other's decisions • Great skill in researching particular issues • Respect differences in each other • Value contribution of others • Care about outcome of the team • Team is solid in discussion • Proactive by starting work early • Many communication channels	• Poor time management • Lack of communication at times • No distinct leader, made it hard to make decisions at times • Other commitments got in the way of meeting regularly • Unfair of distribution of work at stages
Opportunities	Threats
• Labour divided equally among team members • Decisions made on a democracy system • Some setbacks became opportunities as they made us more dedicated	• Falling behind the schedule, delaying all following tasks • No communication with the people of East Timor, made it hard to know if they would actually use our design solution

Table 5: S.W.O.T Analysis Table

Milestones

The team began the project by firstly recognizing the key milestones, and breaking them down further into more specific tasks. This can be seen in the work breakdown structure below. We found that there were six key milestones, which needed to be addressed. These were identify community needs, outline team and project management essentials, generate potential design solutions, select a design solution, build prototype and lastly record results. Some of these sections were so crucial to the project that they have been discussed further in the next section 6.4 Concept and Design Development.

Work Breakdown Structure

1. *Identify Community needs*
   1.1 Research context of East Timor and Codo
   1.2 Research issues in the area
   1.3 Problem identification focusing on development, globalization and poverty reduction
   1.4 Recognize and list needs

2. *Team/Project Management*
   2.1 Team charter and code of conduct
   2.2 Work Breakdown structure
   2.3 Project schedule (Gantt chart)
   2.4 Division of labor
   2.5 SWOT analysis

3. *Generate Potential Design Solutions*
   3.1 Research and analyze potential solutions
   3.2 Brainstorm preliminary designs and possible solutions
   3.3 Analyze preliminary designs
   3.4 How they address specific issues in the social context
   3.5 Design matrix

4. *Select a Design Solution*
   4.1 Design criteria (social, environmental and economic requirements)
   4.2 Technical details and schematics (research resources available)
   4.3 Franklin plot
   4.4 Stakeholder analysis (rainbow plot)
   4.5 Ideal final result diagram
   4.6 Risk assessment analysis

5. *Build Prototype*
   5.1 Acquire necessary resources
   5.2 Assemble mosquito trap

6. *Results*

   6.1 Test prototype in similar weather conditions to Codo

   6.2 Record results based on effectiveness (mosquitos caught)

   6.3 Record results on design life

Concepts and Design Development

We used a series of sub-processes in the development of the concept and design of the mosquito trap. These sub-processes displayed in a network diagram below not only helped the team successfully recognize the best solution but also helped to generate one of originality.

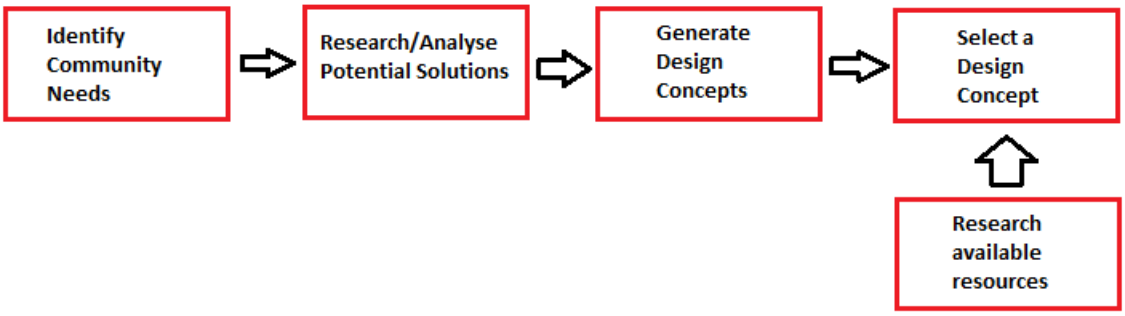


Figure 7: Network Diagram of Concept and Design Development

Identify Community's Needs: This involves thorough research of the context as well as issues that have a dramatic effect on everyday life of the stakeholders. Through this research one can successfully identify the needs of the people and design a solution that addresses these needs. Furthermore it helps researchers develop the necessary information on which to base their design solution.

In order to form a solid understanding of the social context of East Timor and more specifically the Codo area, vast research was undertaken by the group. The information provided by Engineering Without Borders gave a good and brief insight into the life of the Timorese people and helped to develop a general understanding. The group then researched informational web pages, journal articles, research papers, encyclopedias and textbooks to harvest a more detailed understanding of the context

in the given area. All this research material was made available through the University of Western Australia library and online through search engines such as the University of Western Australia's OneSearch and Google Scholar. In doing so, we were able to compile a reliable set of references; these included many from The East Timor Government, AusAID, Engineers Australia and Engineers Without Borders. All are reliable sources as they are all recognized organizations.

Through research of the social context and culture of the East Timor people and specifically the Codo region the team was able to identify the community's needs. The team was able to recognize that one major issue that needs to be addressed is waste management as expressed in the design brief. Further research also showed that Codo also faced many other major issues such as malaria according to Anstey (1999) and poor drinking water according to AusAID (2013). For this reason the team decided that our solution must be one that not only meets the design brief of waste management but also combats one of the other recognized issues. However, because of the poor economic status of East Timor this solution needed to be cost effective and simple.

***Research/Analyze Potential Solutions**:* This sub-process involves researching solutions that have already been used in the community or communities similar to Codo. It then involved analyzing these solutions and determining what made them work or what made them fail.

Generate Design Concepts: Develop a number of design concepts to illustrate what types of designs are both technically feasible and best meet the requirements of the customer's needs. In order to do this successfully the team generated a number of feasible design choices based on research of similar solutions implemented. The team we able to generate a number of designs; some that addressed the need of clean drinking water some that addressed the malaria issue and all of them addressing the waste management issue.

***Select Design Concept/Research Available resources**:* Through the process of evaluation and comparing the different potential solutions a design is chosen. The team evaluated the possible design concepts based on a few main criteria including

sustainability, environmental impact, social impact, cost, feasibility, safety, effectiveness and originality. Through this process the team were able to eliminate other solutions and decide on just one, in this case being the mosquito trap. This sub-process also involves research into available resources, which helps determine the specifications of the chosen design.

Project Schedule

The project schedule was one of the most important aspects of the project. It helped us to recognize key dates in the development of our design and overall project. As a team we created the Gantt chart in Appendix D using our work breakdown structure. Our Gantt chart shows that the project commenced on the 15/08/13 and finished on the 10/10/13 having a total duration of 64 days. As seen on the gantt chart our first key milestone to identify community needs has a duration of 7 days. Our second sub-task is team and project management, which helps identify the schedule and tasks needing to be completed, this took duration of 7 days. The next major milestone was to generate potential design solution, this has duration of 14 days because we needed more time to think critically about the issues allowing us to produce and brainstorm better potential design solutions. The next step is to choose a design solution, which also had duration of 14 days; this gave us substantial time to analyze all solutions and to ensure that we had picked the best possible solution. The last two milestones are to build and test the mosquito trap prototype; these two tasks have a combined duration of 22 days, which allows us enough time to successfully build the prototype and record accurate data.

Conclusion

Based on the results collected off our experimentation and in consideration of the discussion above, the following conclusions have been drawn.

Individuals may choose to use any bottle size of their liking varying from small 250ml to large 2L bottles to trap the mosquitoes, allowing for greater variance of wastes allowed to be recycled and hence reducing a considerable amount of bottle wastage since there are no specific requirements. Furthermore, when considering the average income of individuals within the nation, despite the low cost of ingredients required, a mere 1-teaspoon of sugar and yeast per trap should suffice, having been proven to already have a high level of effectiveness. For a maximum combination of cost, utility and efficiency, the ingredients of the trap should be replaced once every 14 days, based on extrapolating the data on the decreased effectiveness over time.

Brief written instructions of these simple steps will be outlined in the handouts using four languages – English, Portuguese, Tetum and Indonesian. Clear pictures are shown to accommodate those with lower literacy skills in the area, and ensure that every household will be capable of building one with minimum difficulties (refer to figure).

Moreover, we conclude that the design of the trap is expected to be highly efficient in its usage, especially within the nation of Timor Leste. As discussed earlier, Timor Leste is a tropical nation with a much higher rate of mosquito activity than Perth (Whelan and Hapgood, 2001). Considering the success of the trap here, extrapolating the data to a nation with much more favourable conditions, an even greater result can be hypothesized to occur logically.

By considering the core issue of waste management within Timor Leste whilst keeping the health concerns within the region in mind, this proposal has been drafted in accordance to such needs. With these and many other positive externalities such as providing a better environment for the people to live in, this project hopes to empower the community's individuals and make a difference in the lives of the people today.

Recommendations

This project has managed to investigate and determine the effectiveness of a mosquito trap, constructed using only a plastic bottle, with replaceable ingredients – water, yeast and sugar. Being common household ingredients in many areas of the world including those in poverty, this trap provides a good level of utility and recycling, especially in consideration of the various mosquito-borne diseases often prevalent in these areas.

Future exploration may be made into other ingredients that could be used to produce carbon dioxide, which is the main bait of this trap. If other household items that happen to be common in other nations are researched and found, they could be used as substitutes for the convenience of the people of that area. Also, if other similar items with a shape close to those of these plastic bottles are widely thrown and not recycled in other areas of the world, this general concept could prove useful in assisting in managing wastes better in these circumstances.

Also, if possible, investigation should be made into how to further advertise and spread the information about the construction and utilization of this trap within the population of Codo, unto the whole nation of Timor Leste. In order to provide the greatest benefit to both the waste management and health of the nation, as many individuals as possible should be affected by the project, and hence increase the impact on the population as well as the positive externalities resulting from this.

Another highly recommended area to consider for future projects carrying out additional improvements to this proposal would be that of constructing a device or alternate use for the bottle caps used in these plastic bottles. This project acknowledges that one of its constraints is the wastage of the caps during the construction of the mosquito trap, as it serves no purpose in this regard. If an alternate use or mechanism can be constructed from the caps, there will be a 0% wastage level of the bottles used to make these traps, compared to the slight amount of waste we have to accept from the bottle caps.

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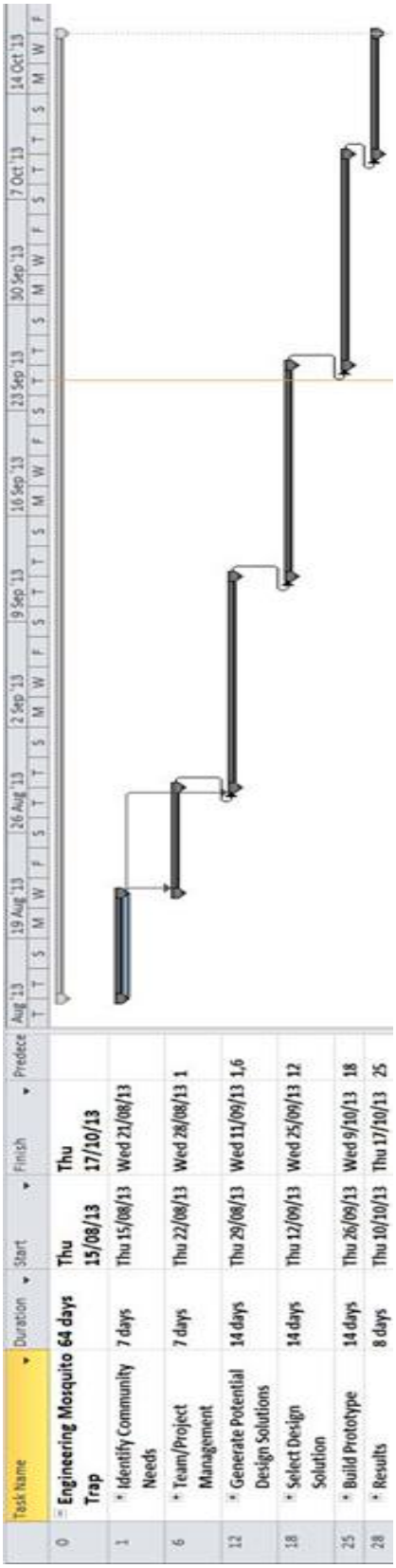
Appendix

Appendix A: Potential Mosquito Trap Flyer – Implementation Device

Figure 8 Mosquito Trap Flyer

Appendix B: Gantt chart Updated

Figure 9 Gantt Chart



	Task Name	Duration	Start	Finish	Predece
0	**Engineering Mosquito Trap**	**64 days**	**Thu 15/08/13**	**Thu 17/10/13**	
1	Identify Community Needs	7 days	Thu 15/08/13	Wed 21/08/13	
6	Team/Project Management	7 days	Thu 22/08/13	Wed 28/08/13	1
12	Generate Potential Design Solutions	14 days	Thu 29/08/13	Wed 11/09/13	1,6
18	Select Design Solution	14 days	Thu 12/09/13	Wed 25/09/13	12
25	Build Prototype	14 days	Thu 26/09/13	Wed 9/10/13	18
28	Results	8 days	Thu 10/10/13	Thu 17/10/13	25